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Weed Control Using Herbicides in Short-rotation Intensively Cultured Poplar Plantations

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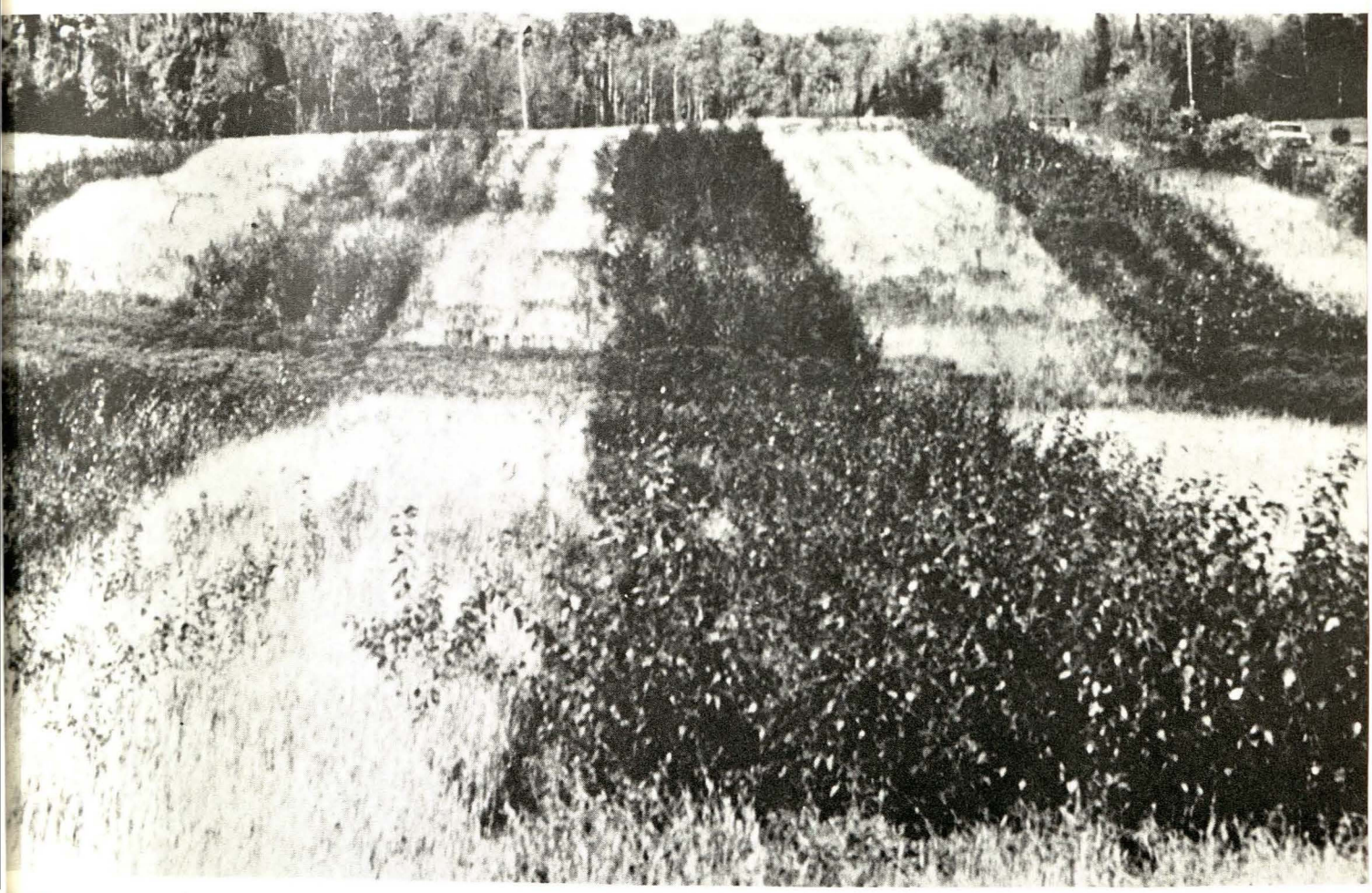

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Summarizes a series of studies that investigated chemical weed control from time of planting to the end of the second growing season. The studies confirm the importance of weed control with preemergents at the time of planting and the importance of additional weed control before the start of the second growing season.

KEY WORDS: Competition, linuron, glyphosate, hybrid poplar.

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WEED CONTROL USING HERBICIDES IN SHORT-ROTATION INTENSIVELY CULTURED POPLAR PLANTATIONS

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Weed control is one of the most critical factors in establishing and managing short-rotation intensively cultured (SRIC) poplar plantations. During 14 years of research on SRIC plantations at Rhinelander, Wisconsin, we have investigated the importance of weed control at various stages of plantation establishment and have developed and tested methods to accomplish satisfactory weed control. Some of these results have been published (Hansen *et al.* 1984, Netzer and Noste 1978) and others have not. This paper summarizes a series of studies that investigated herbicide weed control from the time of planting through the second year of plantation growth. All the studies were on an old field site and most included fertilization and irrigation. In all studies the regular planting material was 20-cm-long unrooted hardwood cuttings. All herbicide dosages given in this paper are in kilograms active ingredient/hectare (kg/ha). The study area was located at the North Central Forest Experiment Station's Harshaw Forestry Research Farm 16 km west of Rhinelander, Wisconsin. The Research Farm has a 50-year history of potato farming. Soils are a Padus series silt loam grading to a sandy loam with a plow layer at 25 cm and a pH ranging from 6 to 7. Quackgrass (*Agropyron repens* (L.) Beauv.) is the main weed competitor; other significant weeds include yellow rocket (*Brassica* spp.), wild mustard (*Brasica kaber* (DC.) Wheeler), lamb's quarters (*chenopodium album* (L.)), white cockle (*Lychnis alba* Mill), marestail (*Conyza canadensis* (L.) Crong.), and pigweed (*Amaranthus retroflexus* (L.)).

WEED CONTROL AT PLANTING

Although poplars are usually planted in clean-tilled weed-free fields, weeds reestablish quickly. The longer that weeds can be controlled with herbicides applied at the time of planting, the larger the poplars will be and the less damage they will receive when additional weed control is needed. Preemergents applied immediately before or after planting can control weed invasion for 4 to 6 weeks or more. In our early research we asked these questions: "Does this initial weed control result in increased tree survival and growth?" and "What herbicides are most successful?" In a 1974-1976 test utilizing three replications of 16-tree plots, we investigated several herbicides and rates including combinations of pre- and postemergents (Netzer and Noste 1978). The results shown in table 1 are from the sod site (1 of 3 sites) that was disked and rototilled before planting. Preemergent linuron was consistently present in those treatments with the best survival and growth.

Further testing of preemergent herbicides in 1980-1983 on 16-tree plots with three replications confirmed that linuron was the best herbicide treatment when applied in spring before planting (table 2). Poplars on plots treated with diphenamid, alachlor, and pronamide grew better than the untreated controls. Napropamide, simazine, and linuron applied in the fall before spring planting resulted in tree growth significantly better than on the control plot that received

Table 1.--*Effect of herbicide treatments on survival and growth of 2-year-old* Populus *cuttings*[1]

Preemergent and dosage	Postemergent and dosage	Poplar	
		Survival	Height
		Percent	*Cm*
Linuron 2,	Paraquat 0.5	40	43
Linuron 2,	Paraquat 0.5[2]	38	36
Linuron 2,		33	43
Linuron 4,		25	43
Linuron 2,	Glyphosate 3,[2]	19	33
Simazine 2,	Paraquat 0.5,[2]	13	40
Simazine 1,		8	9
Simazine 2,	Glyphosate 3,[2]	4	16
Diclobenil 4,		2	8
Simazine 3,		2	6
Diclobenil 4,	Paraquat 0.5,[2]	0	0
- - - control - - -		0	0

[1]Table adapted from tables 2 and 3 in Netzer and Noste 1978.

[2]Postemergent applied in both first and second growing season 0.5,1,2,3,4, = kg of active ingredient/ha.

Table 2.--*Spring applied preemergent herbicides ranked by height of* Populus *'Tristis #1' at the end of the first growing season*

Herbicide	Rate	Tree height
	kg/ha	*cm*
Linuron	2	83[2]
Linuron	1	81
Diphenamid	6	78
Alachlor	2	69
Pronamide	2	69
Linuron/ Alachlor	2/2	65
Oxyfluorfen	0.8	63
Pronamide	1	59
Oxyfluorfen	0.3	58
Napropamide	11	55
Napropamide	13	53
Napropamide	8	52
UNSPRAYED CONTROL		48
Simazine	2	46
Napropamide/ Simazine	13/2	46
Metolachlor	3	45
Matolachlor	2	44

[1]Herbicides were applied to a new set of plots each year for 3 years (1981-1983).

[2]Treatments next to a common line are not significantly different.

no treatment (table 3). Weed competition on the control plot consisted of a dense stand made up equally of wild mustard, white cockle and lamb's quarters.

Another study during 1980-1981 (Hansen *et al.* 1984) compared herbicide treatments with cultivation and use of legume cover crops. The test consisted of a randomized block design with four replications and 6 × 40 m plots of each treatment that were large enough to allow use of common farm implements. The particular treatments tested were some of the best that had been developed over a 6-year period. Once again the treatments containing linuron ranked at or near the top in terms of tree survival:

Weed control treatment	Tree survival
	(Percent)
Glyphosate	81
Linuron-legume	76
Linuron-glyphosate	73
Linuron-cultivation	72
Cultivation	67
Legume	49
Furrow cultivation	35
Furrow cultivation-legume	18

Table 3.--*Fall-applied preemergent herbicides ranked by height of* Populus *'Tristis #1' at the end of the first growing season*

Herbicide[1]	Rate	Tree height
	kg/ha	*cm*
Napropamide	13	78[2]
Simazine	2	74
Linuron	2	73
Napropamide	11	70
Linuron/ Alachlor	2/2	70
Napropamide/ Simazine	13/2	66
Napropamide	8	61
Linuron	1	59
Oxyfluorfen	0.8	58
Diphenamid	6	50
Metolachlor	3	50
Oxadiazon	3	49
Pronamide	2	49
Metolachlor	2	42
Alachlor	2	39
UNSPRAYED CONTROL		38
Oxyfluorfen	0.3	36
Pronamide	1	35

[1]Herbicides were applied the fall before planting to a new set of plots each year for 3 years (1981-1983).

[2]Treatments next to a common line are not significantly different.

The treatments containing linuron also ranked at or near the top in terms of height growth:

Weed control treatment	Tree height
	(m)
Linuron-cultivation	3.2
Linuron-glyphosate	3.2
Cultivation	2.9
Linuron-legume	2.7
Furrow cultivation	2.7
Glyphosate	2.5
Furrow cultivation-legume	2.2
Legume	2.1

In both these tabulations, treatments next to a common line are not significantly different). These results were the same for both irrigated and unirrigated conditions.

Based on these two tests and the extensive use of linuron in routine plantation establishment elsewhere in our research program, we feel that early weed control is essential for plantation establishment, that lin-

uron is the best preemergent of those we have tested on hybrid poplars and that it is a generally safe and effective herbicide. In only 1 year out of 15 did we experience widespread linuron damage when 28 cm of precipitation in June leached linuron into the tree rooting zone.

WEED CONTROL DURING THE FIRST SUMMER

Even with linuron, weeds begin to reinvade so that within 6 weeks after planting many weeds are present. With mid-May planting, the plantations are quite heavily infested with weeds by July. We asked the questions: "Do these weeds compete with the trees?" and "Will significant growth gains occur if the weeds are removed?"

In the first preliminary test, we sprayed glyphosate 2.2 kg/ha using a tractor mounted shield sprayer on July 29, 1980 in a quackgrass infested plantation planted in May at 1 × 1 m spacing. Two 20-m wide strips were sprayed and alternate 20-m wide unsprayed strips were left as controls. Heights of 50 trees/strip were measured within 1 week of herbicide application and again at the end of the first and second growing seasons.

There was no evidence that mid-summer weed control by shielded application of glyphosate resulted in any subsequent increase in height growth (table 4). The data represent average tree height *after* excluding trees obviously damaged by glyphosate. If those trees had been included (about 16 percent), the average tree height of the sprayed strips would have been somewhat less than the unsprayed strips in all cases. We should note that this lack of tree height growth response to weed control was in a fertilized and irrigated plantation where there would be relatively little moisture or nutrient stress because of the weeds. Growth response from weed control might be obtained under less intensive cultural conditions.

Although this preliminary test indicated no effect on tree growth by control of invading weeds by shielded application of glyphosate in mid-summer, it did not clearly demonstrate that such weed control is not potentially beneficial. Damage to trees by glyphosate could have offset potential growth increases from weed control. Therefore, a second study was initiated to determine if careful weed control during the mid-portion of the first growing season results in tree growth gains and if there are some growth losses associated with the herbicides.

Table 4.--*Effect of mid-summer glyphosate spray on subsequent tree height growth*

		Tree height			Growth	
		Pretreatment	Postreatment			
	Treatment	8/6/80	9/9/80	10/6/81	1980	1981
			m			
Reg 1	(Spray	1.40	1.56	3.89	0.16	2.49
	(No Spray	1.19	1.53	3.89	0.34	2.70
Rep 2	(Spray	0.89	1.15	3.31	0.26	2.41
	(No spray	0.85	1.17	2.88	0.32	2.03

Sixteen-tree plots were selected in a newly established plantation that had a tree spacing of 1 × 1 m. These plots were selected to contain trees with uniform growth. Treatments were randomly allocated to each plot, with three replications of each treatment. Tree heights were measured at the time of the first treatment on July 6 and again in the fall after terminal budset.

Treatments were hand-hoeing, a linuron treatment, and a glyphosate treatment, plus an unweeded control plot. Hoeing was done weekly from July 6 through August 4 to a depth less than 2 cm to remove the weeds but minimize damage to the tree roots. Linuron was sprayed at 1.7 kg/ha once over both weeds and trees on July 23 using a hand-held pressurized smallplot sprayer. Glyphosate was applied at 2.2 kg/ha on August 6 with a hand-held ropewick applicator containing a 2:1 mix of water:glyphosate. The control plot received no treatment beyond the preplant linuron application of 1.7 kg/ha that the entire plantation had received. The herbicide applications were delayed for several weeks after the hoeing treatment began to allow the trees to grow larger and thereby possibly minimize damage. All treatments gave good control of weeds.

The analysis did not show any significant differences between treatments in their effect on tree height growth:

Treatment	Height growth
	(m)
Hoe	1.05
Control	1.01
Linuron	0.96
Glyphosate	0.90

The overall analysis of variance was significant only between the 0.05 and 0.10 interval. Hand-hoeing, which gave complete weed control, ranked just marginally better than the control, indicating that complete weed control during the first growing season produces little or no tree growth gains when the site has had good initial site preparation including plowing

and disking followed by a preemergent at time of planting. However, mid-summer weed control may prove beneficial on sites where soil moisture or nutrients are limiting or where weed control has been poor. Both herbicides resulted in some visual tree damage within 2 weeks of application even though extraordinary care was used in hand applying the herbicides. Although the height growth of the sprayed trees was not significantly different from that of the controls, the herbicide damage evident on the trees suggests that the marginal difference in tree growth may have been due to herbicide.

SECOND SEASON WEED CONTROL

By the end of the first growing season, weeds are once again well-established in poplar plantations. With tree spacings 3 × 3 m or greater, equipment can travel between the rows for a few more years so that weed control can be continued throughout the second growing season, if necessary. However, with tree spacings narrower than 3 × 3 m, weed control measures must be applied before second-year tree growth because the trees will rapidly reach a height where a tractor passing over the trees would damage the succulent growing tips. Also, glyphosate applied during the growing season severely damages young poplars. Therefore, we designed a test to determine if there is a time in the late fall or early spring when the actively growing weeds (primarily grasses) are susceptible to herbicide control, but the poplars are still dormant and possibly resistant to the herbicides (Danfield *et al.* 1983). The test consisted of a randomized block design with two replications and 20-tree plots with trees spaced at 1 × 1 m.

Treatments included both fall and spring herbicide applications in a 1-year-old plantation. Fall treatments in 1980 included glyphosate at 1.1 and 2.2 kg/ha; dichlobenil at 4.5 kg/ha; pronamide at 1.1 kg/ha; and hand-hoeing. Treatments were applied October 7, October 20, and November 10, 1980; glyphosate was omitted from the November 10 treatment. The earliest treatment date (October 7) was at least 1 month after bud-set and 2 to 3 weeks before the end of leaf fall. Spring treatments were glyphosate at 1.1 kg/ha; glyphosate at 2.2 kg/ha; glyphosate at 1.1 kg/ha followed 1 week later by an application of linuron at 2.2 kg/ha; and hand-hoeing. Treatments were applied April 15, April 29, May 15, June 4, and June 23, 1981. Dichlobenil at 4.4 kg/ha was applied on only the two early dates. Total tree heights were measured in September 1980 before treatment and again on August 31, 1981, at the end of the second growing season.

Herbicides applied during the dormant season between October 20 and May 15 did not significantly

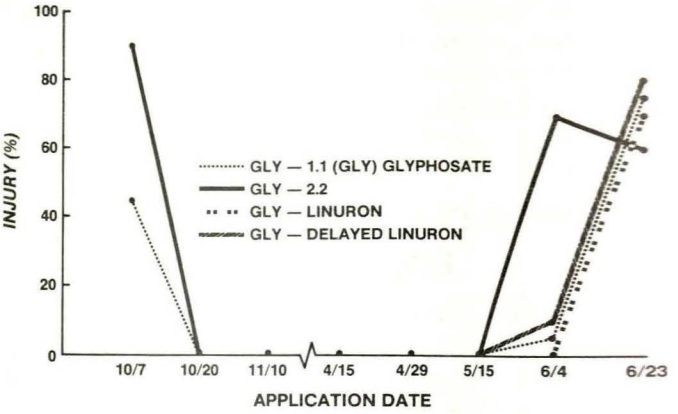

Figure 1.--*Tree injury as related to herbicide and application date.*

injure the trees (fig. 1) or reduce height growth (fig. 2). However, treatments applied earlier in the fall or later in the spring caused varying amounts of injury and reduced tree height growth depending upon the herbicide and application rate. Both dichlobenil and glyphosate controlled competition without injury to the poplars; however, the $580/ha cost of dichlobenil prohibits its use in large plantations. In contrast, glyphosate at a 1.1 kg/ha rate costs $40/ha. This test showed that glyphosate could be safely sprayed over dormant hybrid poplars between October 20 and May 15.

To further test the feasibility of dormant season spraying with glyphosate, we strip sprayed a larger plantation of a 1-year-old clonal mixture in the fall of 1981. Glyphosate was applied at 2.2 kg/ha with a tractor-mounted boom sprayer. Treatments were glyphosate overspraying on October 8 and October 28 plus an unsprayed control. No attempt was made to shield the trees, which were completely leafless. Pretreatment measurements showed an average tree height of 138 cm and 100 percent survival on all plots. Survival at the end of the second growing season (1 year after the overspray) was only 17 and 63 percent for the two clones for the October 8 spray date. However, survival was 100 percent for both the clones for the October

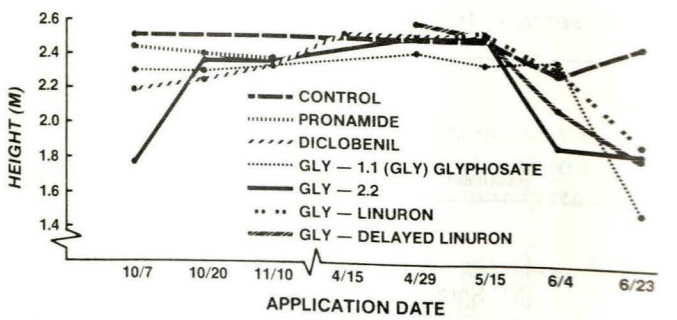

Figure 2.--*Two-year-old tree height as related to herbicide and application date.*

28 spray date and for the unsprayed control plots. Measurements showed that trees sprayed on October 28 were 16 percent taller than the unsprayed controls (18 percent greater second-year growth). In contrast, surviving trees sprayed October 8 were 35 percent shorter than the controls. This test corroborated earlier results by again showing that overspraying with glyphosate in early October damages hybrid poplars and reduces growth but that late October overspraying is safe. In addition, it showed that weed control in the fall of the first year, when done at the proper time, results in increased second-year growth.

We established a final large-scale (5-acre) trial on an old field site to test the suitability of dormant season application of glyphosate on a larger number of clones and to again measure the effects of second-year weed control on tree height growth.

The site was prepared in October 1981 by applying glyphosate at 2.2 kg/ha to control a heavy sod cover consisting mostly of quackgrass. This was followed 1 week later with moldboard plowing and disking. In spring 1982, we applied a preplant treatment of linuron at 2.2 kg/ha. Five hybrid poplar clones were planted as soaked 20-cm hardwood cuttings at 1 × 1 m spacing. Forbs and grasses (mostly quackgrass) began to reinvade the site in late July so that by the end of the first growing season a dense stand of quackgrass covered the site (fig. 3).

Glyphosate was oversprayed at the rate of 1.1 kg/ha to one-half of the area of each clone on May 9, 1983 (spring of the second growing season) at the time the trees were just starting to break bud (green was showing on the buds but leaves had not yet unfurled). As with all previous tests, we did not attempt to shield the trees from the herbicide. Tree growth response to weed control was dramatic (figs. 4 and 5). At the end of the second growing season, trees in the sprayed plots were 12 to 70 percent taller than trees in the unsprayed plots depending on clone (fig. 6). There was no sign of herbicide damage to any clones. This test illustrates that glyphosate may be used safely on a variety of hybrid poplar parentages when oversprayed during the dormant period and that significant second-year height growth gains result. Tests by von Althen (1981) have shown that simazine effectively controls weeds and can be safely used on poplars in the second or later years. But simazine is only marginally effective on quackgrass and will probably not work as well as glyphosate or other herbicides.

Figure 3.--*Quackgrass reinvasion in a 1-year-old hybrid poplar plantation.*

Figure 4.--*Tree height at the end of the second growing season in an unsprayed strip.*

SUMMARY

Weed control with preemergents at the time of planting has a major beneficial effect on survival and growth of hybrid poplars. In our studies, linuron applied at 1½ kg/ha at the time of planting repeatedly gave the best results of the preemergents tested.

Additional weed control in fertilized and irrigated plantations during the first summer did not increase poplar height growth in our tests. We speculate that

Figure 5.--*Tree height at the end of the second growing season in a sprayed strip.*

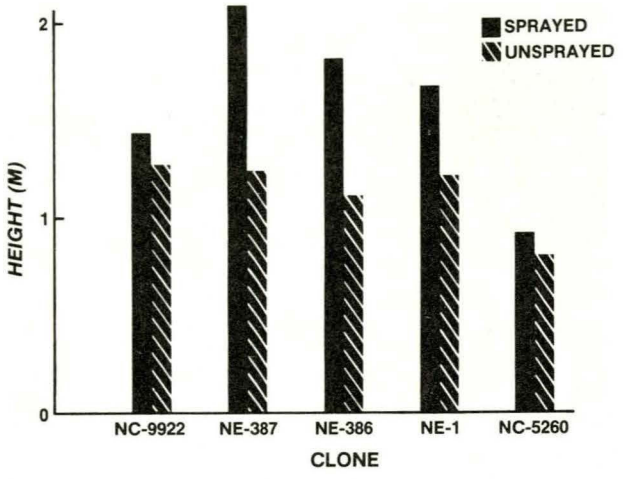

Figure 6.--*Two-year-old hybrid poplars oversprayed with glyphosate at start of second growing season.*

this was because the initial good weed control from preemergents prevented the re-establishment of dense weed cover during the remainder of the growing season. In fact, the risk of tree damage from removing the relatively few weeds during the growing season may greatly outweigh the possible small gains in tree growth. However, mid-summer weed control may prove beneficial on sites where soil moisture or nutrients are limiting or initial weed control has been poor.

Additional weed control before the start of the second growing season can be attained effectively with glyphosate and is essential for promoting rapid growth through the second growing season. Tree damage can be avoided and yet good weed control achieved in northern Wisconsin by broadcast spraying glyphosate at 1 kg/ha after October 15 or before May 15. "Safe" spray dates for other regions may vary to the extent that climate and the associated poplar phenology differ from northern Wisconsin conditions.

These studies illustrate that thorough and repeated weed control is essential to maximize growth of hybrid poplars, and they provide guidelines for achieving good weed control in poplar plantations through the second growing season.

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